Wave Loads on Ships Sailing in Restricted Water Depth

The wave-induced bending moment in ships is the most important sea load parameter for ships larger than 100m in length. Hence, any rational ship design procedure must include a reasonable accurate determination of this load and a large amount of various hydrodynamic formulations have been published, ranging from semi-empirical formulas to three-dimensional non-linear procedures. A review of the state-of-the art can be found in ISSC.VI.1 (2000). These procedures must be combined with operational and sea state information to predict the probability distribution of the maximum wave-induced bending moment a ship may be subjected to during its operational lifetime. Whereas the influence of forward speed and ship heading with respect to the waves usually is accounted for, the effect of water depth is seldom considered, except in non-linear time domain formulations where a confined water domain must be specified anyhow. Usually, two-dimensional strip theories, either linear or non-linear, are applied for actual design cases and these theories are normally based on incident deep-water waves and furthermore apply added mass and damping calculations based on infinite water depth. Only a few papers have in the past addressed the influence of water depth on the ship response. In an early work Kim (1968) presented results for the variation of the added mass and hydrodynamic damping and for the heave and pitch motion for a Series 60 model using a relative motion strip theory formulation. A significant reduction in ship motion with decreasing keel clearance was observed. In the present paper a rigorous implementation of finite water depth in the consistent linear strip theory by Salvesen et al. (1970) is presented together with results for the variation of the motion and wave-induced bending moment with water depth for a container vessel. The results show that if the water depth is less than two times the draft of the vessel, the wave-induced bending moment becomes significant larger than in deep water with the same sea state description. The peak in the frequency response function for the wave bending moment furthermore shift towards lower frequencies with decreasing water depth and thus the influence of the water also depends on the wave energy spectrum.

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